IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:	Art Unit: 1763
Yasumi SAGO, Masayoshi IKEDA, Kazuaki KANEKO and Hiroki DATE	Examiner: Kackar, Ram N.
Serial No. 09/879,934	
Confirmation No. 4444	
Filed: June 14, 2001	
For: Electro-static Chucking Mechanism and Surface Processing Apparatus	

DECLARATION UNDER 37 CFR 1.132

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

We, Yasumi SAGO, Masayoshi IKEDA, Kazuaki KANEKO and Hiroki DATE, hereby declare as follows:

Use of helium as a heat exchange gas in a heat exchange concave having a depth in a range of 1 to less than 20 micrometers, as we claim in this application, is critical to our invention and produces results that are not expected from the prior art of record.

Gas molecules existing in a gap between a substrate and an electrostatic chuck (ESC) transfer heat between one another. In an etching apparatus, for example, a substrate is cooled by an ESC. Gas molecules between the substrate and the ESC deprive the substrate of heat and transfer the heat to the ESC. Heat is transferred most efficiently when a molecule travels from the substrate to the ESC without colliding with another molecule. By contrast, when a molecule collides with another molecule after receiving heat from the substrate, heat is transferred to the other molecule, and not to the ESC. Thus, heat transfer efficiency decreases.

As known, the distance that a molecule travels without colliding with another molecule is defined as its *length of mean free path*. Therefore, the heat transfer between a substrate and an ESC in a case where the gap distance (d) between the substrate and ESC is shorter than the length of mean free path (L)

must be considered separately from a case where the gap distance (d) is longer than the length of mean free path (L).

When d is shorter than L, a molecule travels from the substrate to the ESC, on average, without any collisions with other molecules. Therefore, under constant pressure, the heat transfer coefficient is constant and is not dependent on the gap distance (d), so long as d<L. In this case, the heat transfer coefficient essentially depends on molecular density (N), thermal capacity (c), average gas velocity (v).

$h \sim Ncv \sim N/\sqrt{Z}$ (formula 1), where

h: heat transfer coefficient;

N: molecular density;

c: thermal capacity;

v: average gas velocity;

and

Z: molecular weight.

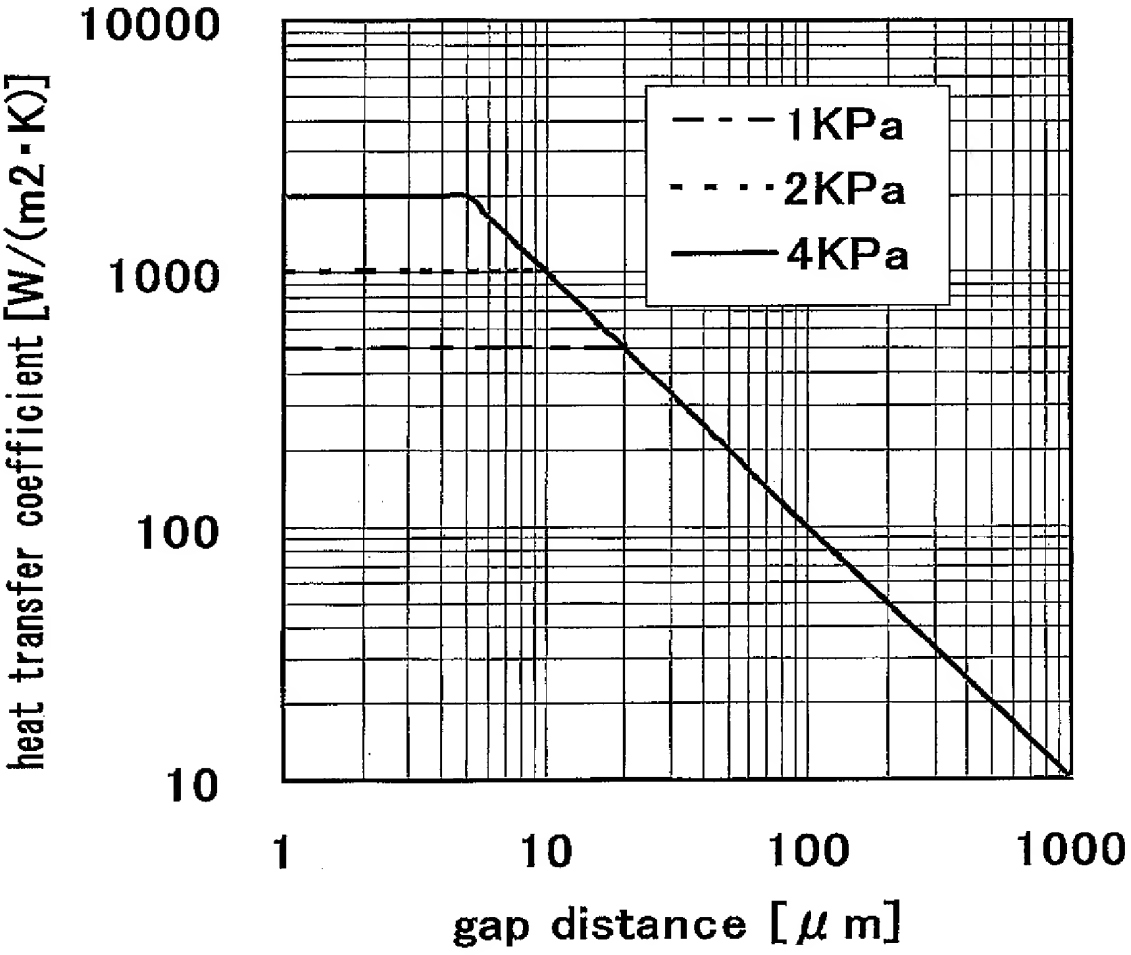
"~" in the formula indicates a proportional relation. When d is longer than L, by contrast, a molecule travels from the substrate to the ESC, on average, with collisions with other molecules. The heat transfer coefficient therefore depends on the number of collisions with other molecules. The number of collisions is expressed as d/L. As the number of collisions increases, the heat transfer coefficient decreases. That is, the number of collisions is inversely proportional to the heat transfer coefficient. Thus, when d is longer than L, the formula 1 is modified as follows:

$h \sim NL/(d\sqrt{Z}) \sim 1/(Sd\sqrt{(2Z)})$ (formula 2), where

L: length of mean free path; and

S: collision cross section.

The following graph shows the heat transfer coefficient calculated according to these formulas, when the heat exchange gas is helium. The gas transfer coefficient is calculated under helium gas pressures, respectively, of 1 kPa, 2 kPa and 4 kPa.



As shown, at a pressure of 1 kPa, which is roughly equal to 10 Torr and is the practical pressure of a heat exchange gas between a substrate and an ESC, the heat transfer coefficient is constant up to a gap distance of 20 micrometers. When the gap distance exceeds 20 micrometers, the heat transfer coefficient immediately begins to decrease. Thus, 20 micrometers is the critical gap distance for helium at 1 kPa (≈ 10 Torr). Of course, this means that length of mean free path of helium at 1 kPa is approximately 20 micrometers.

Moreover, as noted in paragraph [0027] of our specification, at gap distances below 1 micrometer, the conductance in the heat exchange concave decreases greatly and causes the temperature of the substrate to become non-uniform. Thus, in view of this data, use of helium as a heat exchange gas in a

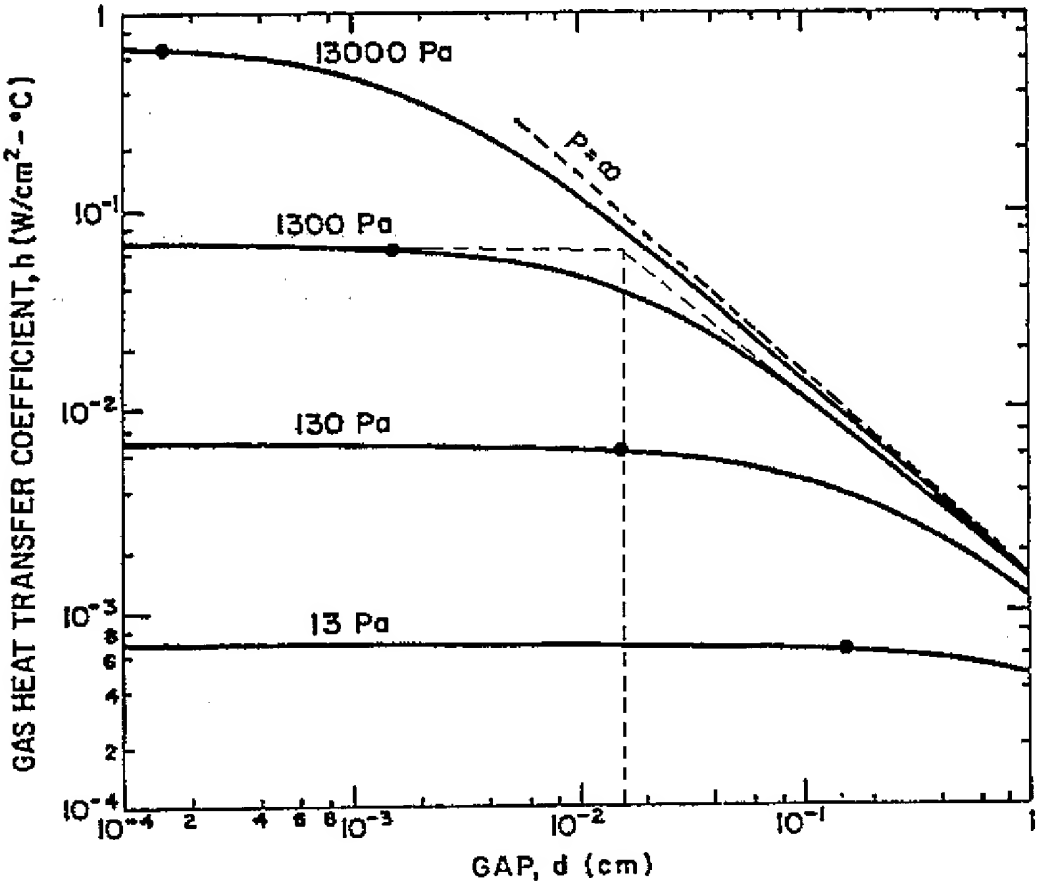
heat exchange concave having a depth in a range of 1 to less than 20 micrometers is critical and produces results that are not expected from the prior art of record.

In particular, United States patent 5,810,933 to Mountsier (Fig. 9) is cited as the most relevant prior art. However, Fig. 9 of Mountsier shows the relationship of pressure to heat transfer coefficient *for hydrogen gas*, and is not relevant to use of helium gas as a heat exchange gas. Hydrogen gas has a different length of mean free path from helium. Thus, introducing hydrogen gas into heat exchange concaves having a gap distance in a range of 1 to less than 20 micrometers will not produce the critical and unexpected results that are produced when helium gas is used in combination with heat exchange concaves with a gap distance in a range of 1 to less than 20 micrometers (i.e. constant heat transfer coefficient within this range only).

Mountsier describes 20 to 35 micrometers is preferable as a dot height H_D, i.e., the gap distance, in column 10 at lines 64-65. In the same paragraph, Mountsier describes that the degradation of heat transfer performance is illustrated in FIG.. 9 for the dot heights H_D of 20, 50 and 100 micrometers. As known, since cross section of a helium gas molecule, which is a monoatomic molecule, is smaller than that of a hydrogen gas molecule, the length of mean free pass of helium is longer than that of hydrogen. In the concept of our invention, if a gas of a longer length of mean free path is used, the critical point of the gap distance shifts to a greater value. Therefore, if an optimum range for hydrogen is 20 to 35 micrometers, an optimum range for helium must be greater than 20 to 35 micrometers. In this respect as well, the gap distance of 1 to less than 20 micrometers for helium is unexpected from the disclosure by Mountsier.

In addition, we would like to bring another reference that is exemplary of the state of the prior art to the attention of the Office for purposes of comparison with our invention. Attached are pages 358-359 of "Plasma Etching" by Denis M. Manos et al., 1989, Academic Press Inc. ("Manos"). FIGURE 8 at page 358 of Manos shows the dependence of the heat transfer coefficient on pressure and a gap for helium. There is no description of how the curves in FIGURE 8 were obtained. In FIGURE 8, the heat transfer coefficient at 1300 Pa (nearly equal to 10 Torr) gradually increases as a gap distance is reduced, where the gap distance is approximately 0.02 cm (i.e., 200 micrometers) or more. Where the gap distance is reduced below 0.02 cm, the heat transfer coefficient at 1300 Pa saturates and becomes almost constant

For checking a critical point of the gradual increase range and the constant range, we drew auxiliary lines in Manos' FIGURE 8. This is shown below:



As shown, the intersection of the line tangent to the nearly constant range and the line tangent to the gradual increase range is adjacent to 0.02 cm. This is, accordingly, different from the critical point of our invention, i.e., 20 micrometers, in about one order (approximately a ten-times difference). One of ordinary skill in the art looking at this figure will realize that the critical point at 1300Pa is approximately 0.02 cm. Therefore, a range of 1 to less than 20 micrometers would not be expected from Manos, or any other known prior art.

The undersigned, having been warned that willful false statements and the like are punishable by fine or imprisonment, or both(18 USC 1001), and may jeopardize the validity of this application or any patent issuing therefrom, hereby declares that all statement's made of my own knowledge are true and that all statements made on information and belief are believed to be true.

Inventor's Signature Yasumi Sago Date: January 23, 2007

Yasumi SAGO

Inventor's Signature _____ Date: _____

Masayoshi IKEDA

Inventor's Signature _____ Date: _____

Kazuaki KANEKO

Inventor's Signature _____ Date: _____

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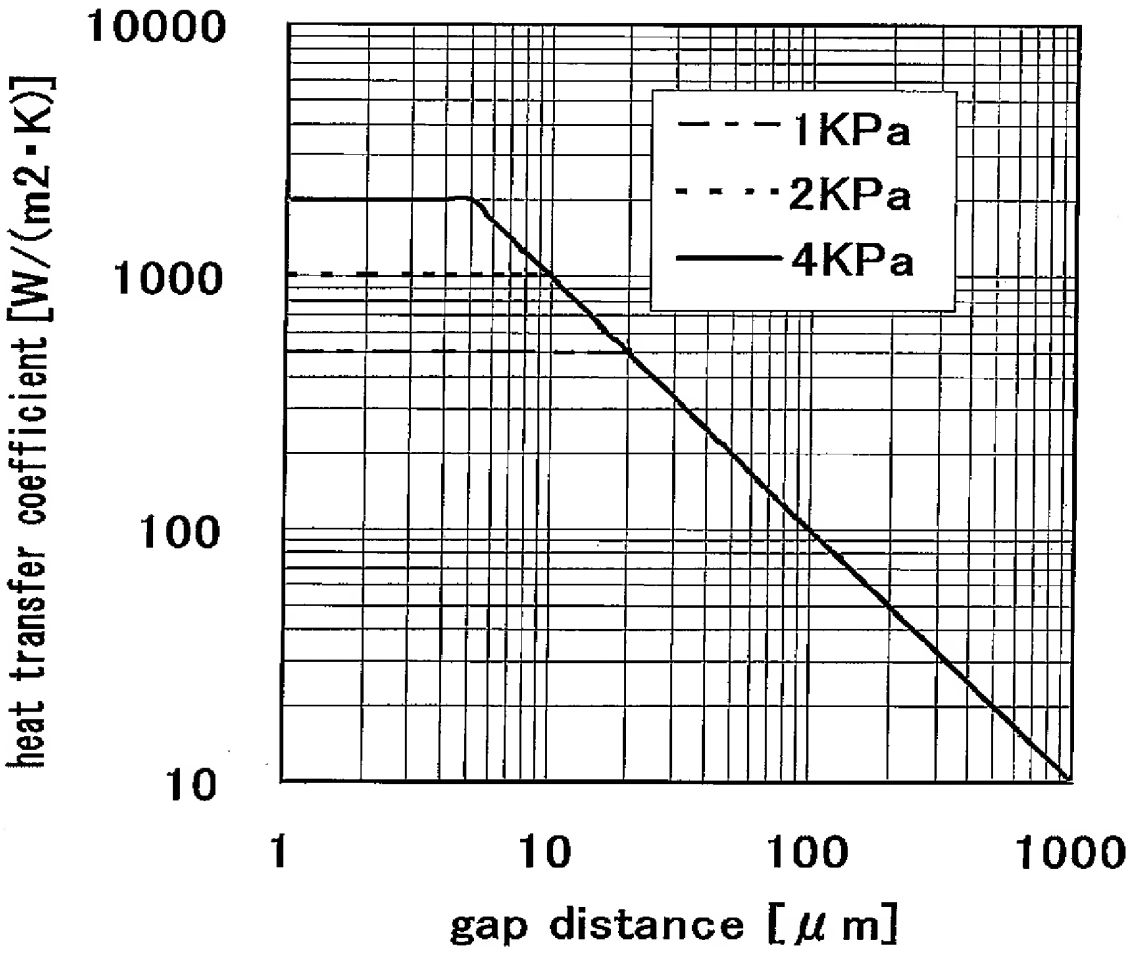

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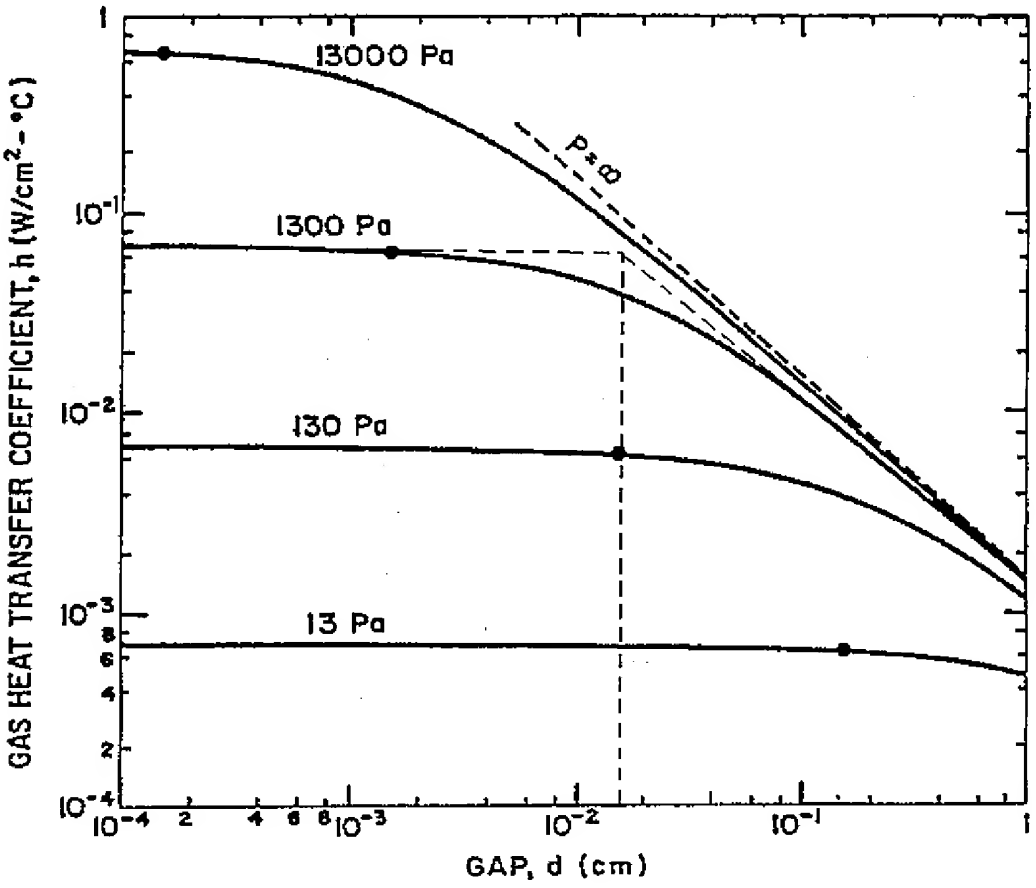

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Inventor's Signature _____ Date:_____

Yasumi SAGO

Inventor's Signature Masayoshi Ikeda Date: January 23, 2007

Masayoshi IKEDA

Inventor's Signature Kazuaki Kaneko Date: January 23, 2007

Kazuaki KANEKO

Inventor's Signature Hiroki Date Date: January 23, 2007

Hiroki DATE